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6. AUTHOR(S)
Daniel C. Tsui

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Princeton University
Department of Electrical Engineering
Engineering Quadrangle
Princeton, New Jersey 08544-5263

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13. ABSTRACT *(Maximum 200 Words)*
Earlier, under the previous AFOSR grant, we found direct experimental evidence for the composite fermion model of the Fractional quantum Hall effect. The composite fermion (CF) is the quasiparticle of an electron bound to two magnetic flux quanta by virtue fo the strong electron-electron interaction in the 2D system. The CF's are weakly interacting and experience no external magnetic field at Landau level filling v=1/2. This report summarizes results from subsequent experiments on these composite particles, carried out under the AF Grant no. F49620-95-1-0071. More specifically: (1) their effective mass, (2) their effective g-factor, and (3) the CF with four flux quanta.

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Department of Electrical Engineering
Princeton University

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I. Introduction

This is a final report on the research carried out under the Air Force Grant No. F49620-95-1-0071, covering the period from 1994 to 1997. The research focuses on the physical properties of composite fermions (CF) which are the new particles realized in two-dimensional electron systems (2DES) in strong magnetic fields. More specifically, at Landau level filling factor $\nu = ½$, ratio of the 2D electron density to the magnetic flux density applied to the 2DES is ½. The new particle is a composite of one electron bound with two magnetic flux quanta, by virtue of the strong electron-electron interaction in the system, and it experiences no magnetic field at $\nu = ½$. For ν away from $\nu = ½$, it experiences an effective magnetic field given by $B_{eff} = B - B_{½}$, where $B_{½}$ is the field at $\nu = ½$. The CF's are weakly interacting particles and Landau quantization of their single particle energy spectrum into discrete levels gives rise to the energy gaps of the prominent fractional quantum Hall effect series at $\nu = p/(2p \pm 1)$. The experiments briefly summarized below yield first experimental data on the CF's mass and g-factor, and also the CF's with flux quanta.

II. Experiments and Results

A. **Drastic enhancement of CF near Landau level filling $\nu = ½$.** We have determined the effective mass of composite fermions in the vicinity of half Landau level filling and observe a mass enhancement by as much as 40% as the filling factor v approaches v= ½ (Fig. 1). These measurements provide the first experimental data for the energetics of this novel fermion system as $\nu \rightarrow ½$. The apparently divergent particle mass indicates that the system at exactly ν= ½ is not an ordinary Fermi liquid. Also, it is important to point out that the mass derived from this experiment is unrelated to the cyclotron mass of the electron. The CF mass is exclusively a consequence of electron-electron interaction, and hence, for a given fraction exclusively a function of electron density. This generation of a mass solely from electron-electron interactions is a manifestation of the strange physics we have here.

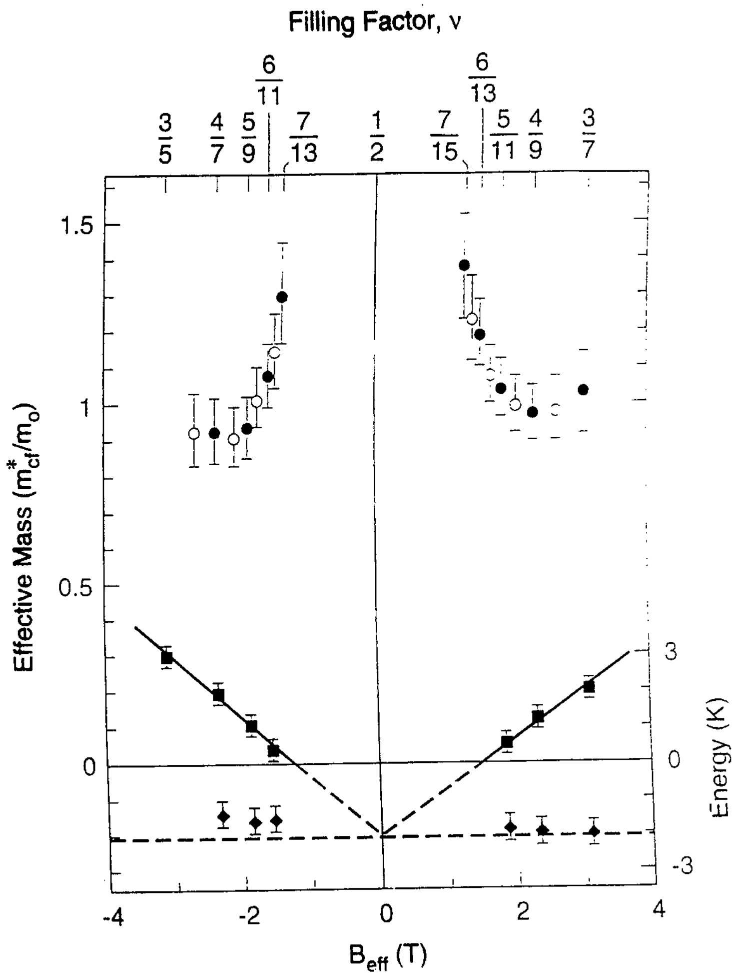

FIGURE 1: Magnetic field dependence of the energy gaps of fractional quantum Hall states at filling factors ν=p/(2p ±1) around ν= ½ as determined from thermal activation energy measurements on a sample of density n=0.83x10^{11}cm^{-2}. Lines are a guide to the eye. Gaps are clearly opening roughly linearly with an *effective* magnetic field, whose origin is at ν= ½. It is reminiscent of the opening of landau gaps for electrons around B=0. Therefore, the FQHE states around ν=½ can be viewed as arising from the landau quantization of new particles, so-called composite fermions (CFs), that consist of electrons to which two magnetic flux-quanta have been bound by virtue of the electron-electron interaction. Their mass, m^*~0.532-0.63 m_o, is unrelated to the electron mass and of purely many-particle origin. The negative intercept at exactly ν= ½ is believed to be a result of level broadening which closes the gaps at small fields. (Du el al., 1993)

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B. **Fractional quantum Hall effect around $\nu = 3/2$: composite fermions with a spin.** Angular dependent magnetotransport measurements on the fractional Hall (FQHE) states around Landau level filling factor $\nu = 3/2$ are explained very effectively in terms of composite fermions (CFs) with a spin. The disappearance and reappearance of FQHE states as well as their spin polarization is deduced from a simple "Landau level" fan diagram for CFs. While the "Landau splitting" scales with *effective* magnetic field, with its origin at $\nu = 3/2$, the spin-splitting scales with *total* external magnetic field having its origin at $B=0$. The g factor of a CF is largely the g factor of the electron. More specifically, $g^* = 0.61 + 0.083\ B_{eff}$, where B_{eff} is in unit of Tesla.

C. **Effective mass and g-factor of composite fermions with four flux quanta.** Previous experimental work on composite fermions has concentrated almost exclusively on composite fermions with two attached flux quanta and very little has been established on composite fermions with greater flux attachment. We have carried out an extensive investigation of the properties of a four flux composite fermion. Magnetotransport measurements in tilted magnetic fields on the fractional quantum Hall states near Landau level filling factor $\nu = ¾$ can be understood in terms of composite fermion with spin. The effective mass and g-factor of the four flux composite fermion are remarkably similar to those of the two flux composite fermion at $\nu = 1/2$ and $3/2$.

III. Publications of Work Supported by Contract

1. "Experimental Evidence for New Particles in the Fractional Quantum Hall Effect," R.R. Du, H.L. Stormer, D.C. Tsui, L.N. Pfeiffer, and K.W. West, Physical Review Letters 70, 2944 (1993).
2. "Shubnikov-deHaas Oscillations Around $\nu = 1/2$ Landau Level Filling Factor," R.R. Du, H.L. Stormer, D.C. Tsui, L.N. Pfeiffer, and K.W. West, Solid State Communications 90, 71 (1994).
3. "Drastic Enhancement of Composite Fermion Mass near Landau Level Filling $\nu = 1/2$," R.R. Du, H.L. Stormer, D.C. Tsui, A.S. Yeh, L.N. Pfeiffer, and K.W. West, Physical Review Letters 73, 3274 (1994).
4. "Fractional Quantum Hall Effect around v = 3/2: Composite Fermions with a Spin," R.R. Du, H.L. Stormer, D.C. Tsui, A.S. Yeh, L.N. Pfeiffer, and K.W. West, Physical Review Letters 75, 3926 (1995).
5. "Composite Fermions around Landau Level Filling Factor $\nu = 3/2$," R.R. Du, A.S. Yeh, H.L. Stormer, D.C. Tsui, L.N. Pfeiffer, and K.W. West, Surface Science 361/362, 26 (1996).

6. "Fractional Quantum Hall Liquid to Insulator Transition in the Vicinity of Landau Level Filling $\nu = 2/9$," R.R. Du, H.L. Stormer, D.C. Tsui, L.N. Pfeiffer, and K.W. West, Solid State Communications 99, 755 (1996).

7. "g-Factor of Composite Fermions around $\nu = 3/2$ from Angular-Dependent Activation-Energy Measurements," R.R. Du, A.S. Yeh, H.L. Stormer, D.C Tsui, L.N. Pfeiffer, and K.W. West, Physical Review B 55, R7531 (1997).

IV. Personnel Supported by Contract

1. Graduate Students

Andrew Yeh, Ph.D., 1997, Department of Physics, Princeton University. Presently with NEC Research Institute, Princeton, NJ.

2. Post-docs

Rui R. Du, presently faculty member, Physics Department, University of Utah.

Jongsoo Yoon, Ph.D. from Physics Department, Penn State.